

AUTECOLOGICAL ASPECTS OF *DIAPENSIA LAPPONICA*
L.
IN NEWFOUNDLAND

ROBIN T. DAY¹ AND PETER J. SCOTT

Diapensia laponica L. is an arctic-alpine species that is adapted to cool windswept habitats and reaches its southeastern limit in North America in Newfoundland and New England (Fig. 1). It can survive immersion in liquid nitrogen (-196°C ., Sakai and Otsuka, 1970) and it grows in the most exposed and windswept habitats of Mt. Washington, New Hampshire (Tiffney, 1972) where the world's windspeed record was recorded at 374 km/hr (Bliss, 1963).

Damman (1976) suggests that this species is restricted to areas with cool summer temperatures. In addition, competition and pedology appear to be important in restricting its distribution. This species is most often found on acid soils; however, it is also common at Trout River in western Newfoundland on the serpentine soils which have toxic and low nutrient properties that exclude many of the potential competitors. In other areas, competitors may be eliminated or reduced by conditions during the fall, winter, and spring: soil disruption during the frequent freeze-thaw cycles, and abrasion and desiccation caused by high winds. Where climate and soil do not maintain a low vegetation, *Diapensia laponica* clumps are invaded and overgrown by competing species.

Diapensia laponica plants form domes or mats, and growth form studies by Day (1978) suggest that in addition to being adapted to destructive windy habitats these forms act as solar heat traps. In vertical section, domed growth forms have a hemispherical shape (Fig. 3) while mat forms are flattened. During 1977 the microhabitat of *Diapensia* was monitored with nine temperature probes recording at half-hour intervals (Grant Miniature Recorder Model D). On sunny spring days the leaf surface of a small *Diapensia* plant often exceeded the temperature of any other object in the environment by as much as 8°C at 8:00 a.m. and by progressively lesser amounts until 3:00 p.m. (daylight savings time). In addition, the soil beneath these plants was the warmest location in the environment from 8:00 p.m. to

¹Present address: Department of Biology, University of New Brunswick, Fredericton, N.B., E3B 5A3, Canada

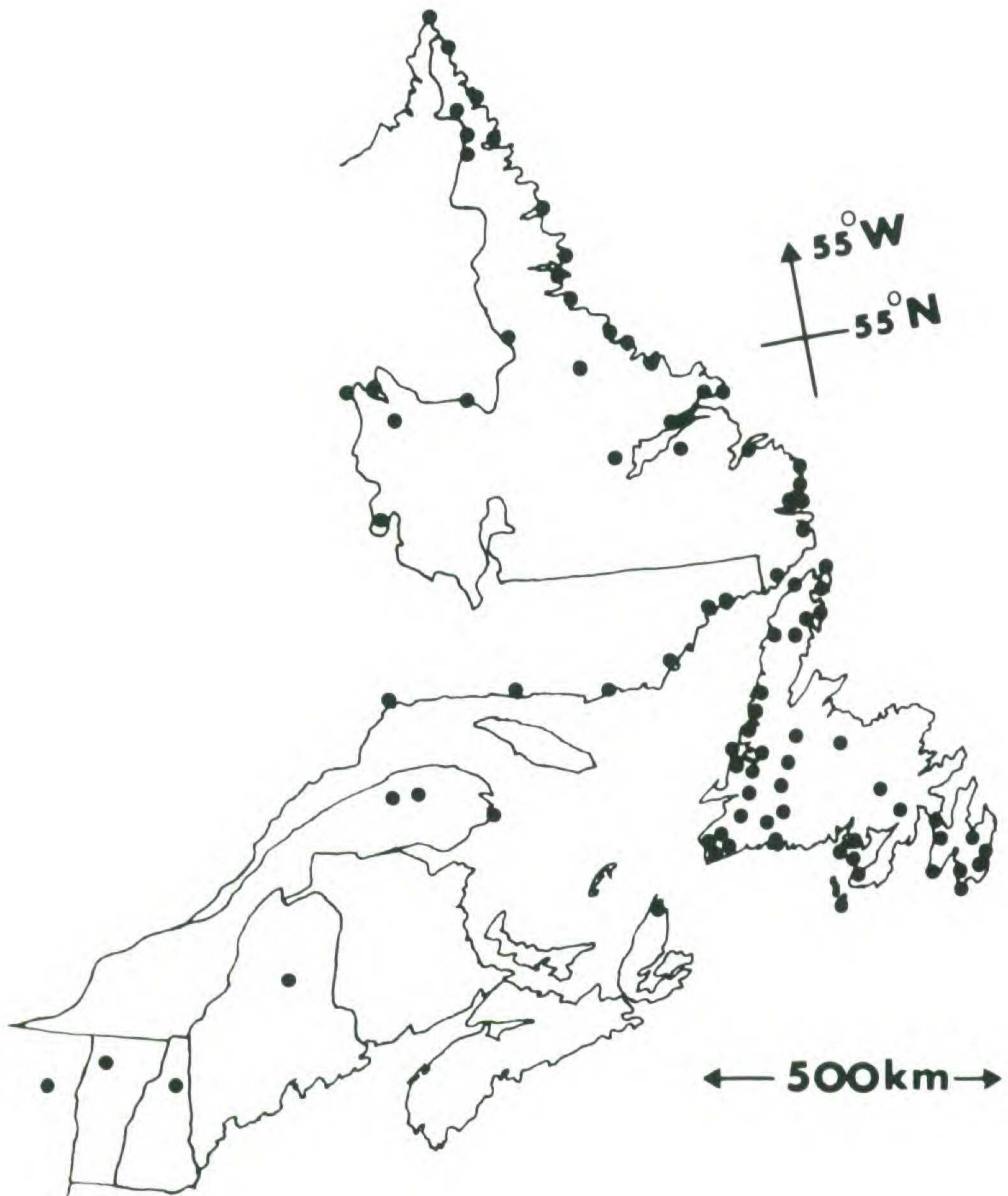


Figure 1. Distribution Map of *Diapensia* in Northeastern North America.

midnight. These observations certainly support a heat trap hypothesis. At low altitudes and in coastal areas without frequent fogs the trapping of excess heat would be damaging if respiration or transpiration could not be controlled. Perhaps it is *Diapensia's* inability to control these functions at high temperatures that restrict it in its southern range to habitats with cool summer temperatures like the exposed hill tops and foggy coastal fringes of Newfoundland. The difficulties with cultivating *D. lapponica* at Oxen Pond Botanic

Park in St. John's and elsewhere in the world (Blakelock, 1952; Griffith, 1964) can probably be attributed to excess heating of these growth forms at lower altitudes.

The distribution maps of *Diapensia lapponica* (Figs. 1 & 2) are primarily an extension of the work of Damman (1976). The additional sites of interest are St. Pierre and Brunette Island, St. Shotts, Point Lance, and Barachois Park in Newfoundland. The major source of information was the Agnes Marion Ayre Herbarium of Memorial University of Newfoundland (NFLD). The collections of the Federal Agriculture Station and Newfoundland Forest Research Centre in St. John's were also examined. Because *Diapensia* is so unmistakable in the field, verbal reports were accepted from trained botanists. In addition, the following literature sources were used: Lysaght, 1971; Hounsell and Smith, 1966; Damman, 1976; Smith and Erskine, 1954; Hustich and Pettersson, 1943; Fernald, 1907; and Rousseau, 1974.

AN AUGUST-BLOOMING POPULATION OF *DIAPENSIA LAPPONICA* L.

In mid-May 1975 it was observed that flower buds were present on some plants but absent from others on the Hawke Hills of the Avalon Peninsula. The buds opened in June and the mature plants that did not bloom then flowered in August. This August-blooming population was considered a local anomaly until Mr. Richard Cannings (pers. comm.) reported that most of the *Diapensia lapponica* plants at Cape St. Mary's bloomed in August and that the June-blooming plants were in the minority. Observations (1975–1979) show that June-bloomers flower from May 19 to June 20 with a peak in the first week of June, and August-bloomers flower from June 29 to August 29 or later with a peak in the first week of August. There is no overlap of blooming periods.

A review of the available herbarium material from Newfoundland was undertaken and by examining for the presence or absence of flowers and flower buds and the condition of the fruit it was possible to designate a specimen as being a June- or an August-bloomer. August-blooming populations have been documented from the following locations on the island of Newfoundland (Fig. 2). *West Coast Sites*: —1. Gregory Plateau; 2. Weebald Island. *Avalon Peninsula Sites*: 3. Peters River; 4. Doe Hills, Isthmus of Avalon; 5.

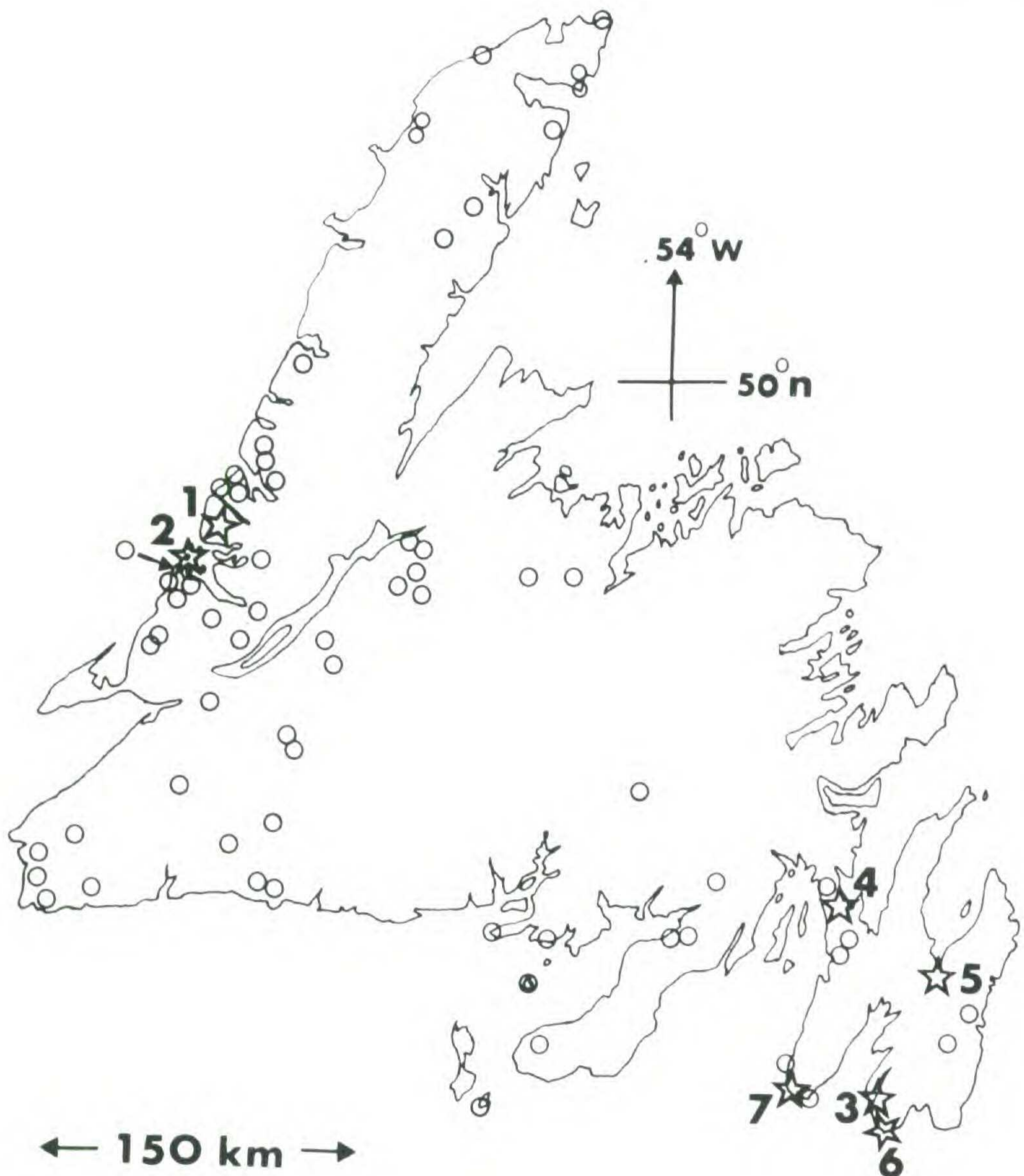


Figure 2. Distribution map of *Diapensia* on the island of Newfoundland. Circles represent *D. lapponica* sites and stars indicate populations with August-blooming plants. Numbers are referred to in the text.

Hawke Hills, south of Holyrood; 6. St. Shotts; 7. Cape St. Mary's.

The phenology of the two populations at Hawke Hills was recorded from 1975 to 1979 and plants of both population types maintained their characteristic blooming periods through the five years of observation. There may be as many as fifty flowers/year on very large plants with each flower giving rise to a mean production of 121 seeds/capsule. This production is never actually realized because

an infection of the seeds and capsules by the Pyrenomycete *Apiothyrium arcticum* Petrak (identified by M.P. Corlett of Agriculture Canada Research Branch, Biosystematics Research Institute, Ottawa) leads to a mortality of approximately 40% of the seeds. Furthermore it was discovered that the June-blooming plants formed their flower buds in the previous year while the August-blooming plants formed theirs in the same year as flowering. A similar situation is known for separate arctic and alpine populations of *Saxifraga cernua* L. (Wehrmeister & Bonde, 1977). June-bloomers disperse their seeds in late summer while the August-bloomers release their seeds in the winter when they can potentially be dispersed by blowing over the snow crust. The capsules from the August bloom were found projecting through the snow, dehisced, and with mature seed on January 7, 1978 at the Hawke Hills. Eleven days after thawing, seeds collected on December 19, 1978 from August-blooming plants were germinated. These observations affirm the biological significance of the August bloom for *Diapensia lapponica*.

The authors presently believe that August-blooming is typically found in most, if not all, populations of *Diapensia lapponica* on the island of Newfoundland, as all known *Diapensia* locations visited have had August-blooming plants. The August-bloomers can be found in mixed or separate groups on a series of knolls within any one locality and so one would assume some degree of geographically-induced reproductive isolation—one of the first steps in speciation.

A review of the literature shows that August-blooming has not been reported for *Diapensia lapponica* (Table 1); however, Dr. W. H. Drury (College of Atlantic, Bar Harbor, Maine) and Dr. R. E. Graber (Northeastern Forest Experiment Station, U.S. Forest Service, Durham, New Hampshire) have both stated (pers. comm.) that a late bloom occurs on Mt. Washington, New Hampshire.

Second blooming periods have been reported for a number of other arctic-alpine species with the usual flowering period in the spring and an anomalous one later in the summer. Aleksandrova (1961) found that *Ranunculus sulphureus* Sol. and *R. sabinei* R. Br. bloom in spring (June 26 to July 12) and late summer (August 10 to 25) but he does not make it clear if individual plants flower twice or if two separate populations exist. Löve (1963) suggests that this situation is temperature-controlled. Gjaerevoll (1967, p. 14) reports that in central Alaska *Rhododendron lapponicum* (L.) Wahlenb. "was frequently seen flowering for the second time in August".

Table 1. Flowering Period of *Diapensia lapponica* L. in Various Areas of its Distribution.

Authority	Flowering Information	Location
Bliss, 1962	June 1959	Mt. Washington, New Hampshire
Harris, 1940	... past flowering by the middle of July and often before July 4th.	Presidential Range, New Hampshire
Weeden, 1968	1962 to 1967 inclusive Earliest start—31 May Latest start—9 June Average start—6 June	Central Alaska
Ohwi, 1965	June to July	Japan
Petersen, 1912	Start—12 June Start—13 June	Greenland Scoresby Sound Karajak (in the west)
Fernald, 1950; Gleason, 1952	June, July	Northeastern North America
Fiedler, 1939	23 June	Abisko, Sweden
Tikhomirov & Gavrilyuk, 1966	June to July	Bering Coast of Chukhi Peninsula

INDIVIDUAL PLANTS OR POPULATIONS?

Individual plants of *Silene acaulis* L. bloom twice. Mr. B. S. Jackson observed that two plants of *S. acaulis* which had been transplanted from Cape St. Mary's, Newfoundland in 1972, bloom twice a year at Oxen Pond Botanic Park, St. John's, Newfoundland. The second blooming consists of fewer flowers than the first. The second blooming may be temperature-controlled as in *Ranunculus* or the longer-than-normal growing season at its southern range limit may permit or, perhaps, induce the second blooming. Cultivars and native clones of *Rubus idaeus* L. show a parallel phenology.

Anomalous phenologies were thought to be environmentally induced. In his discussion of relic species, Cain cites Wulff (1932, 1943) as providing... "a series of instances of lack of harmony between some species and their conditions. This lack of harmony shows itself in relic species, in lack of co-ordination between periodicity of growth and rhythms of climate, in incomplete life cycles, in the dying out of relic species, etc.". (Cain, 1944, p. 20-21). Whether the second blooming could be considered adaptive or not would depend upon whether or not it produces viable seeds.

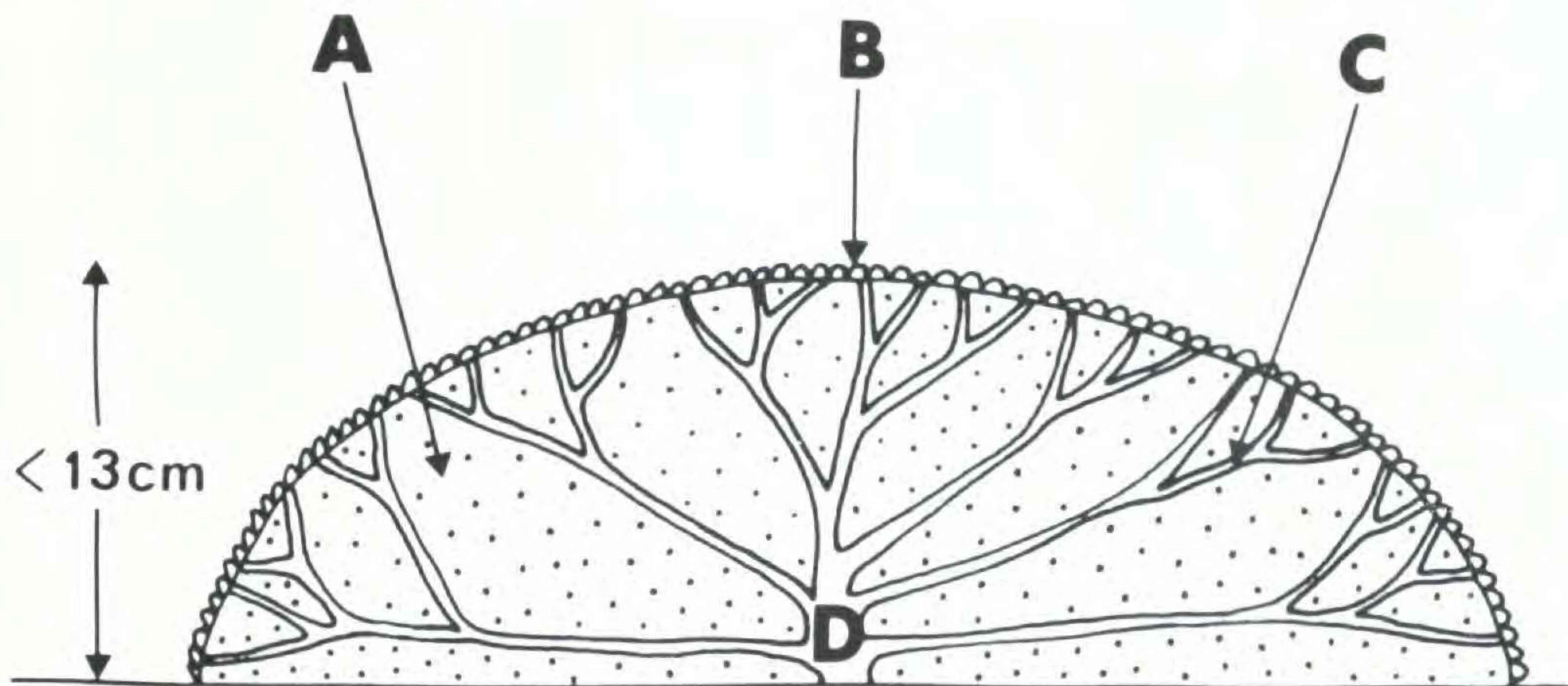


Figure 3. Cross-section of the domed growth form of *Diapensia lapponica* L., illustrating supporting dead leaves (A), superficial shell of living leaves (B), long thin branches (C), and main stem (D).

Anomalous flowering periods may be produced by environmental conditions alone or may be genetically determined as may be the case with *Diapensia lapponica*. This has not been determined yet because of the difficulties in culturing the species. While it could be argued that microclimate instead of genetics would determine the blooming period of the individual, the occurrence of both types in a microhabitat at the Hawke Hills, Doe Hills, and Cape St. Mary's would suggest otherwise.

Day (1978) speculates about the origin and evolution of the August-blooming population and the question of recognizing it as a new biological species (*sensu* Grant, 1971) arises. The two populations appear to be reproductively isolated since there is no overlap in blooming periods; however, does this isolation persist beyond one generation? Can a June-blooming plant produce August-bloomers and *vice versa*? If this were the situation then gene flow could occur over several generations and the concept of a new biological species would not be applicable. Alternately, the two blooming periods may be controlled by one or several genes. Such a situation has been found in *Rosa* spp. (Semeniuk, 1971; Svejda, 1977) and *Fragaria* spp. (Anonymous, 1937) which exhibit recurrent blooming. Until the inheritance of the blooming periods in *Diapensia lapponica* has been determined, no taxonomic treatment can be suggested.

ACKNOWLEDGEMENTS

We would like to thank Dr. Leo Dionne for his helpful suggestions concerning this paper and G. Brassard, R. Cannings, G. Fontaine, R. Hooper, J. Maunder, B. Roberts, G. Ryan, and A. Whittick for their distribution reports.

BIBLIOGRAPHY

- ALEKSANDROVA, V. C. 1961. Seasonal Dynamics of Arctic Plant Communities. *Problemy Severa* **4**: 59-74.
- ANONYMOUS. 1937. Yearbook of Agriculture. United States Dept. of Agriculture, Washington.
- BLAKELOCK, R. A. 1952. *Diapensia lapponica*: Its Occurrence in Scotland. *Kew Bull.* **3**: 325-326.
- BLISS, L. C. 1962. Caloric and lipid content in alpine tundra plants. *Ecology* **43**: 753-757.
- . 1963. Alpine plant communities of the Presidential Range, New Hampshire. *Ecology* **44**: 678-697.
- CAIN, S. A. 1944. Foundations in Plant Geography. MacMillan, N.Y.
- DAMMAN, A. W. H. 1976. Plant distribution in Newfoundland especially in relation to summer temperatures measured with the sucrose inversion method. *Canad. J. Bot.* **54**: 1561-1585.
- DAY, R. T. 1978. The autecology of *Diapensia lapponica* L. in Newfoundland. B.Sc. (Hons.) Dissertation, Memorial University of Newfoundland.
- FERNALD, M. L. 1907. The soil preferences of certain alpine and subalpine plants. *Rhodora* **9**: 149-193.
- FERNALD, M. L. 1950. Gray's Manual of Botany. 8th ed. (corrected printing, 1970). Van Nostrand Co., N.Y.
- FIEDLER, S. G. 1939. In quest of *Cassiope hypnoides*. *Bull. Alpine Garden Society* **7**: 344-377.
- GJAEREVOLL, O. 1967. Botanical investigations in Central Alaska, especially in the White Mountains. D.K.N.V.S. Skrifter NR10. 63 pp.
- GLEASON, H. A. 1952. The new Britton and Brown illustrated flora of the north-eastern United States and adjacent Canada. Hafner, N.Y. 3 vols.
- GRANT, V. 1971. Plant speciation. Columbia Univ. Press, N.Y.
- GRIFFITH, A. 1964. A guide to rock garden plants. Dutton, N.Y.
- HARRIS, S. K. 1940. Heaths of the Presidential Range. *Appalachia*. June 24-34.
- HOUNSELL, R. W., & E. C. SMITH. 1966. Contributions to the flora of Nova Scotia VIII. Distribution of arctic-alpine and boreal disjuncts. *Rhodora* **68**: 409-419.
- HUSTICH, I., & B. PETTERSSON. 1943. Notes on vascular plants of the east coast of Newfoundland Labrador. I. Preliminary list of plants. *Memo. Soc. Fauna Flora Fenn.* **8**: 192-200.
- LÖVE, D. 1963. Dispersal and Survival of Plants. *In* North Atlantic biota and their history. MacMillan Co., N.Y.
- LYSAGHT, A. M. 1971. Joseph Banks in Newfoundland and Labrador, 1766: his

- diary, manuscripts and collections. Faber & Faber, London.
- OHWI, J. 1965. Flora of Japan. Smithsonian Inst., Washington, D.C.
- PETERSEN, H. E. 1912. The structure and biology of arctic flowering plants 1. Ericineae. 2. Diapensiaceae. Medd. Gronl. **36, 37**: 140-154, 76-138.
- ROUSSEAU, C. 1974. Géographie floristique Québec-Labrador. Distribution des principales espèces vasculaires. Les Presses de l'Université Laval, Québec.
- SAKAI, A., & K. OTSUKA. 1970. Freezing resistance of alpine plants. Ecology **51**: 665-671.
- SEMENIUK, P. 1971. Inheritance of recurrent and nonrecurrent blooming in 'Goldilocks' × *Rosa wichuraiana* progeny. J. Hered. **62**: 319-320.
- SMITH, E. C. & J. S. ERSKINE. 1954. Contributions to the flora of Nova Scotia IV. *Rhodora* **56**: 242-252.
- SVEJDA, F. 1977. Breeding for improvement of flowering attributes of winterhardy *Rosa rugosa* hybrids. Euphytica **26**: 697-701.
- TIFFNEY, W. N. 1972. Snow cover and the *Diapensia lapponica* habitat in the White Mountains, New Hampshire. *Rhodora* **74**: 358-377.
- TIKHOMIROV, B. A., & V. A. GAVRILYUK. 1966. The flora of the Bering coast of Chukhi Peninsula. In: Vegetation of the far north of the U.S.S.R. and its utilization. Akademiya Nauk SSSR Botanicheskii Institut im. V. L. Komarova. Israel Prog. Sci. Trans. 1969. 79-105.
- WEEDEN, R. B. 1968. Dates of first flowers of alpine plants at Eagle Creek, Central Alaska. *Canad. Field-Nat.* **82**: 24-31.
- WEHRMEISTER, R. R., & E. K. BONDE. 1977. Comparative aspects of growth and reproductive biology in arctic and alpine populations of *Saxifraga cernua* L. *Arct. Alp. Res.* **9**: 401-406.
- WULFF, E. V. 1932. Introduction to the historical geography of plants. *Bull. Applied Bot. Suppl.* **52**: 325-335.
- . 1943. An introduction to historical plant geography. *Chronica Botanica*, Waltham, Mass.

DEPARTMENT OF BIOLOGY
MEMORIAL UNIVERSITY OF NEWFOUNDLAND,
ST. JOHN'S NEWFOUNDLAND
A1B 3X9, CANADA